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(54) **ADAPTIVE TURBO DECISION FEEDBACK EQUALIZATION METHOD AND DEVICE**

(75) Inventors: **Vinayak Tripathi**, Schaumburg, IL (US); **Michael L. Honig**, Evanston, IL (US)

(73) Assignee: **Motorola, Inc.**, Schaumburg, IL (US)

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H04B 3/20 (2006.01)
H04B 7/216 (2006.01)

(52) **U.S. Cl.** **375/233**; 370/286; 370/342

(58) **Field of Classification Search** 375/233, 375/232

See application file for complete search history.

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Primary Examiner—Chieh M. Fan
Assistant Examiner—Cicely Ware

(57) **ABSTRACT**

The invention provides an adaptive turbo decision feedback equalizer for executing an adaptive turbo decision feedback equalization method in response to a reception a packet including samples transmitted to the adaptive turbo decision feedback equalizer via a channel. The adaptive turbo decision feedback equalizer generates a first set of soft estimates of bits based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimation of the channel. The adaptive turbo decision feedback equalizer subsequently generates additional sets of soft estimates of the bits and a set of hard estimates of the bits based upon a computation of additional feed-forward filters and additional feedback filters as a function of a plurality of additional soft symbol estimates.

27 Claims, 3 Drawing Sheets

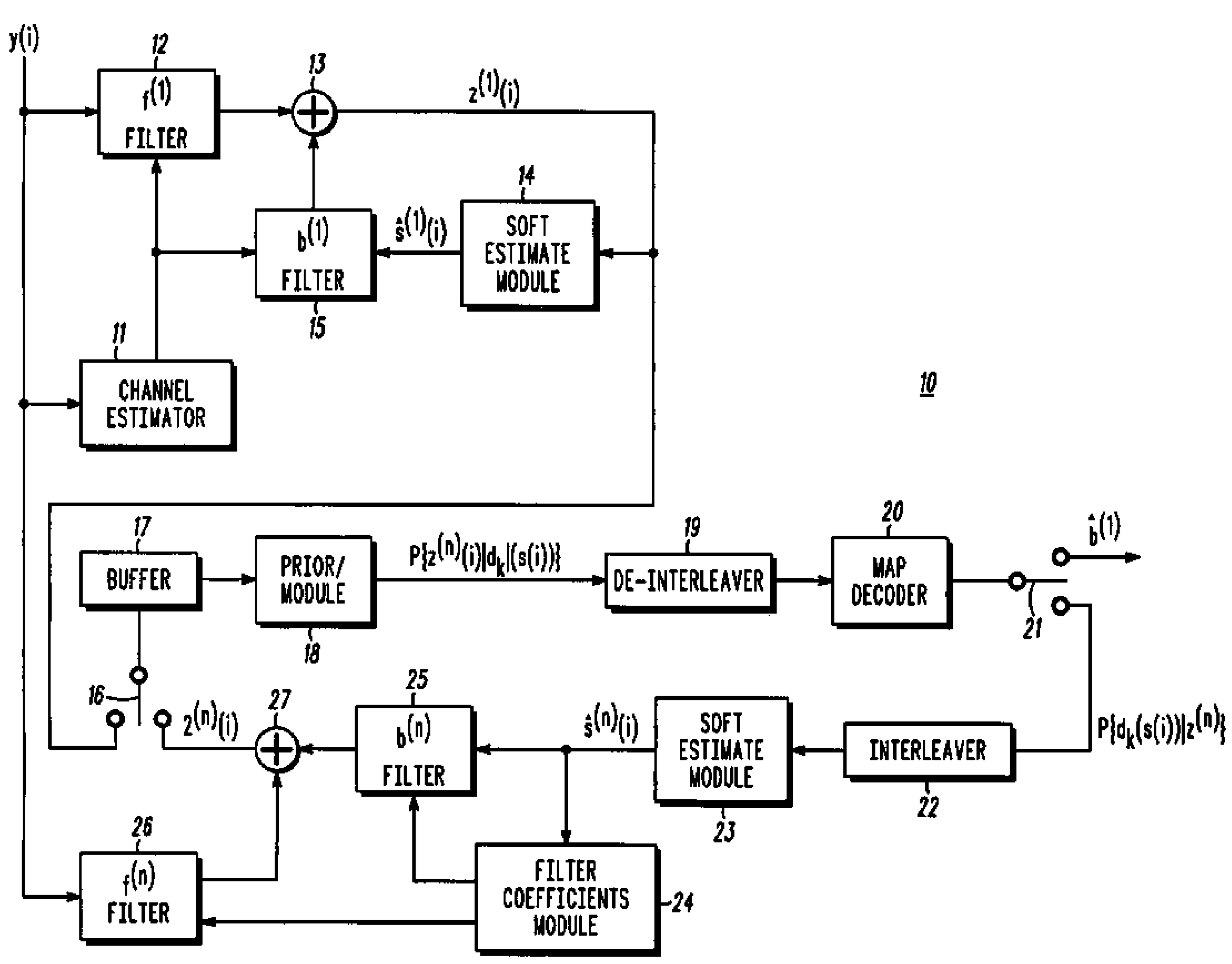
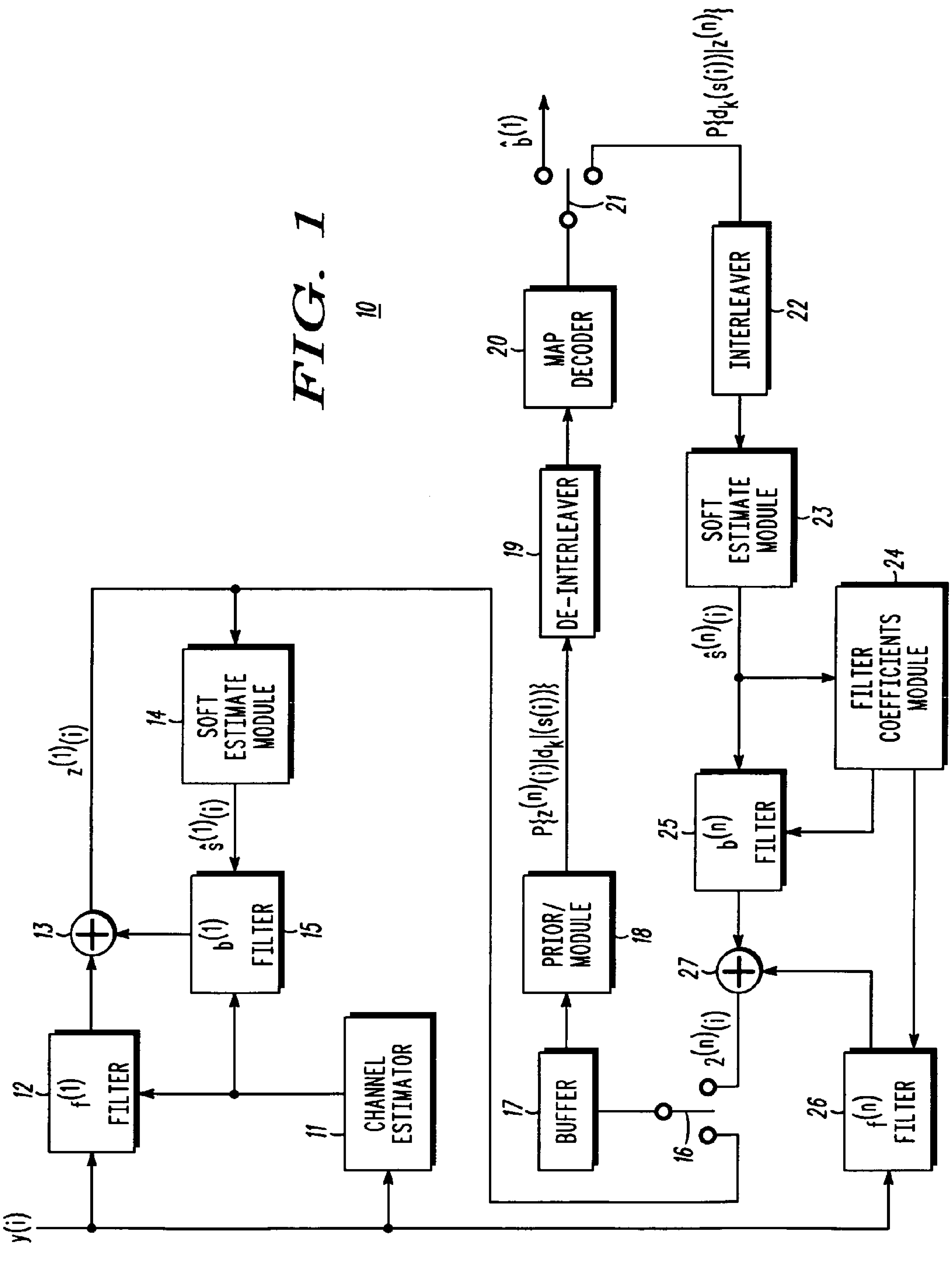
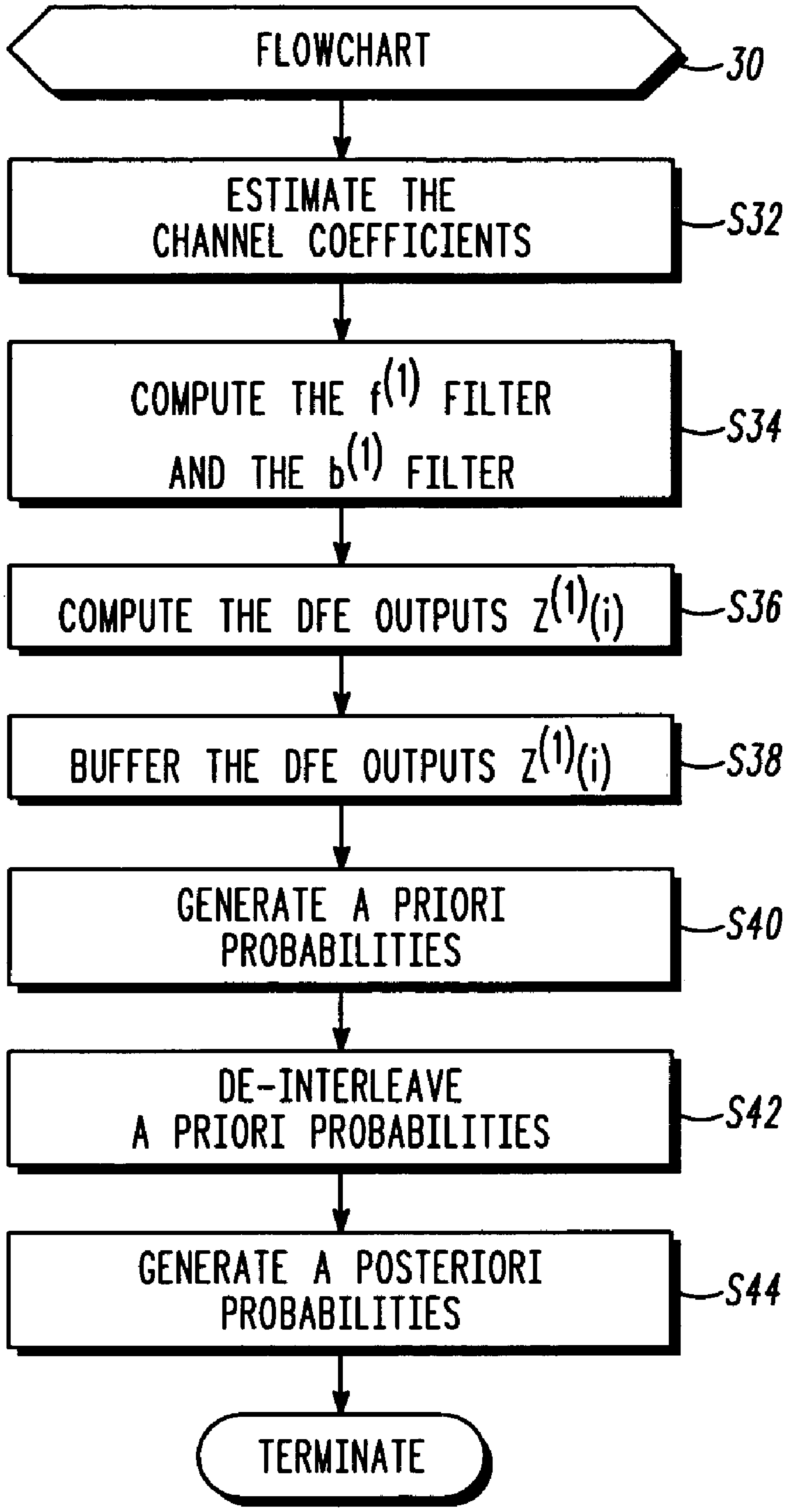


FIG. 1


10
CHANNEL ESTIMATOR
11
$f^{(1)}$ FILTER
12
13
$b^{(1)}$ FILTER
15
SOFT ESTIMATE MODULE
14
$\hat{s}^{(1)}(i)$
$z^{(1)}(i)$
$y(i)$
16
BUFFER
17
PRIOR/ MODULE
18
$P\{z^{(n)}(i)|d_k(s(i))\}$
DE-INTERLEAVER
19
MAP DECODER
20
21
$\hat{b}^{(1)}$
$P\{d_k(s(i))|z^{(n)}\}$
INTERLEAVER
22
SOFT ESTIMATE MODULE
23
$\hat{s}^{(n)}(i)$
FILTER COEFFICIENTS MODULE
24
$b^{(n)}$ FILTER
25
$f^{(n)}$ FILTER
26
27
$z^{(n)}(i)$



FLOWCHART
30
ESTIMATE THE CHANNEL COEFFICIENTS
S32
COMPUTE THE $f^{(1)}$ FILTER AND THE $b^{(1)}$ FILTER
S34
COMPUTE THE DFE OUTPUTS $z^{(1)}(i)$
S36
BUFFER THE DFE OUTPUTS $z^{(1)}(i)$
S38
GENERATE A PRIORI PROBABILITIES
S40
DE-INTERLEAVE A PRIORI PROBABILITIES
S42
GENERATE A POSTERIORI PROBABILITIES
S44
TERMINATE

FIG. 2

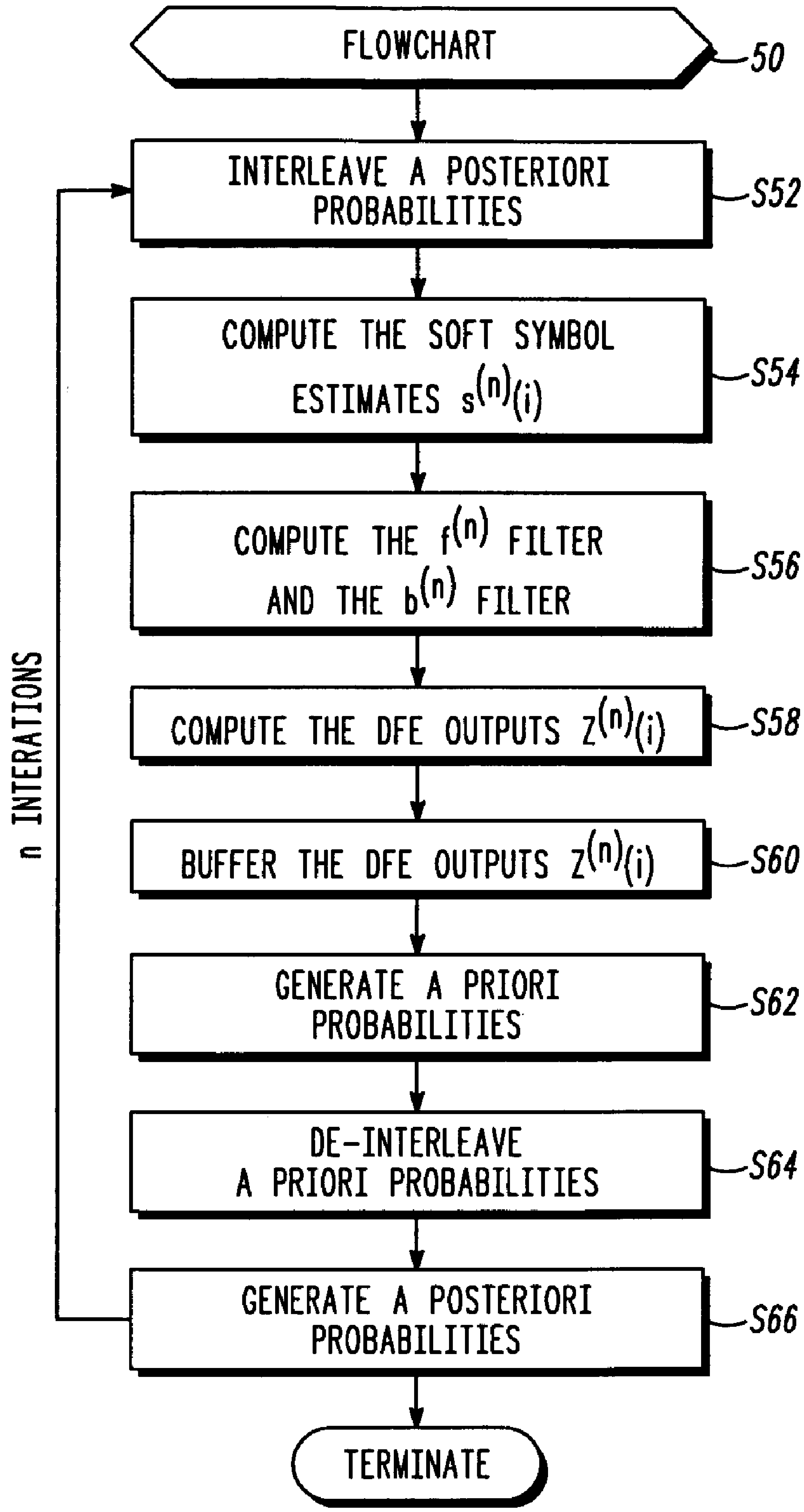

FLOWCHART
50
INTERLEAVE A POSTERIORI PROBABILITIES
S52
COMPUTE THE SOFT SYMBOL ESTIMATES $s^{(n)}(i)$
S54
COMPUTE THE $f^{(n)}$ FILTER AND THE $b^{(n)}$ FILTER
S56
COMPUTE THE DFE OUTPUTS $z^{(n)}(i)$
S58
BUFFER THE DFE OUTPUTS $z^{(n)}(i)$
S60
GENERATE A PRIORI PROBABILITIES
S62
DE-INTERLEAVE A PRIORI PROBABILITIES
S64
GENERATE A POSTERIORI PROBABILITIES
S66
n INTERATIONS
TERMINATE

FIG. 3

ADAPTIVE TURBO DECISION FEEDBACK EQUALIZATION METHOD AND DEVICE

FIELD OF THE INVENTION

The present invention generally relates to the field of communication systems. More specifically, the invention relates to turbo decision-feedback equalization techniques implemented in a cellular system operating with a multi-path channel.

BACKGROUND OF THE INVENTION

The capacity of a cellular system operating with a multi-path channel can be limited by a demodulator's ability to mitigate the degradations of the received signal due to the multi-path channel. One receiver known in the art for receiving coded transmissions over a multi-path channel is a maximum likelihood sequence estimator ("MLSE") that operates to jointly demodulate the channel and the error correction code. However, the complexity of an MLSE is proportional to P^{L+K}, where P is the number of points in a signal constellation, K is the number of stages in a convolutional code shift register, and L is the number of symbol spaced taps of the multi-path channel. Such complexity impedes an implementation of the MLSE into a cellular system.

Another known receiver for receiving coded transmissions over a multi-path channel is a turbo decision-feedback equalizer ("TDFE") having feed-forward filters and feedback filters that are based upon an estimation of the multi-path channel. While the complexity of the TDFE does not impede the implementation of the TDFE into a cellular system, a problem with the TDFE is the computation of the filters assumes perfect feedback that is not attained in practice.

Therefore, there is a need for an adaptive TDFE. The present invention addresses this need.

SUMMARY OF THE INVENTION

One form of the invention is a method for decoding a packet transmitted over a channel with the packet including a plurality of samples. First, a first set of soft estimates of a plurality of bits is generated based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimate of the channel. Second, a second set of soft estimates of the plurality of bits is generated based upon a computation of a second feed-forward filter and a second feedback filter as a function of a first set of soft symbol estimates.

A second form of the invention is a device decoding a packet transmitted over a channel with the packet including a plurality of samples. The device includes means for generating a first set of soft estimates of a plurality of bits based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimate of the channel, and means for generating a second set of soft estimates of the plurality of bits based upon a computation of a second feed-forward filter and a second feedback filter as a function of a first set of soft symbol estimates.

A third form of the present invention is a computer readable medium storing a computer program comprising computer readable code for generating a first set of soft estimates of a plurality of bits based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimate of the channel, and computer readable code for generating a second set of soft estimates of the plurality of bits based upon a computation of a second feed-forward filter and a second feedback filter as a function of a first set of soft symbol estimates.

The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiment, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention rather than limiting, the scope of the invention being defined by the appended claims and equivalents thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of one embodiment of an adaptive turbo decision feedback equalizer for receiving a packet over a channel in accordance with the present invention;

FIG. **2** is a flowchart illustrating one embodiment of a decision feedback equalization method for generating soft estimates of the bits as known in the art; and

FIG. **3** is a flowchart illustrating one embodiment of an adaptive decision feedback equalization method for generating soft and hard estimates of the bits in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

FIG. **1** illustrates an adaptive turbo decision-feedback equalizer **10** ("adaptive TDFE **10**") in accordance with one embodiment of the present invention. From the subsequent description herein of the adaptive TDFE **10**, those having ordinary skill in the art will appreciate an employment of the adaptive TDFE **10** into a receiver whereby a transmitter transmits a packet including a M Q-ary modulated data symbols and training symbols containing bits, and the adaptive TDFE **10** receives a packet y including samples y(i) corresponding to the data symbols and training symbols. In one embodiment, the transmitted packet contains 8-Phase Shift Keying (8-PSK) symbols wherein samples y(i) are represented by the following equation [1]:

$$y(i)=Hs(i)+n(i) \tag{1}$$

where the vector of received samples y(i) in the packet y is given by the following equation [2]:

$$y(i)=\begin{bmatrix} y_{i+\delta-1} \\ y_{i+\delta-2} \\ \vdots \\ y_{i+\delta-N_f} \end{bmatrix}, \tag{2}$$

the Toeplitz channel impulse response matrix H of dimensions $N_f \times (N_f+L-1)$ is given by the following equation [3]:

$$H=\begin{bmatrix} h_0 & \cdots & h_{L-1} & 0 & \cdots & \cdots & 0 \\ 0 & h_0 & \cdots & h_{L-1} & & & \vdots \\ \vdots & & \ddots & & \ddots & & \vdots \\ 0 & \cdots & \cdots & \cdots & h_0 & \cdots & h_{L-1} \end{bmatrix} \tag{3}$$

and, the transmitted symbol vector s(i) is defined in accordance with the following equation [4]:

$$s(i)=\begin{bmatrix} s_{i+\delta-1} \\ s_{i+\delta-2} \\ \vdots \\ s_i \\ \vdots \\ s_{i+\delta-N_f-L-1} \end{bmatrix} \quad [4]$$

In the equations [1]–[4], s(i) represents three coded bits $\{d_k(s(i)), k=1,2,3\}$; n(i) is a vector of noise samples; N_f is the length of a feed-forward filter **12**; and δ is a delay for optimizing the adaptive TDFE **10**.

In response to a reception of the packet y, the adaptive TDFE **10** executes a flowchart **30** as illustrated in the FIG. **2** and a flowchart **50** as illustrated in the FIG. **3**. The flowchart **30** is representative of a decision feedback equalization method for generating a soft estimate of bits within the transmitted packet, and the flowchart **50** is representative of an adaptive decision feedback equalization method for generating soft estimates and hard estimates of the bits within the transmitted packet. The various components of the adaptive TDFE **10** will now be described herein in the context of a sequential execution of the flowchart **30** and the flowchart **50**.

Referring to FIGS. **1** and **2**, the adaptive TDFE **10** has a first component stage for executing the flowchart **30**. This first component stage includes a channel estimator **11**, a feed-forward filter **12** ("$f^{(1)}$ filter **12**"), an adder **13**, a soft estimate module **14**, and a feedback filter **15** ("$b^{(1)}$ filter **15**") constituting a decision feedback equalizer ("DFE"). The first component stage further includes a switch **16**, a buffer **17**, an a priori probability module **18** ("a priori module **18**"), a de-interleaver **19**, and a Map decoder **20**. During a block S**32** of the flowchart **30**, the channel estimator **11** estimates the channel coefficients. In one embodiment, the channel estimator **11** estimates the channel coefficients in accordance with the following equations [5] and [6]:

$$[\hat{h}_0, \hat{h}_1, \ldots \hat{h}_{L-1}]^1 = \arg\min_h \|y_\Gamma - Th\|^2 = (T^H T)^{-1} T^H y_T \quad [5]$$

$$\hat{\sigma}_n^2 = \frac{1}{T}\left\|y_T - T\hat{h}\right\|^2 \quad [6]$$

where y_T is the T×1 vector of the received training symbols represented by the following equation [7]:

$$y_T=\begin{bmatrix} y_L \\ y_{L+1} \\ \vdots \\ y_T \end{bmatrix} \quad [7]$$

and the matrix T is a Toeplitz matrix of transmitted training symbols s_i that is given by the following equation [8]:

$$T=\begin{bmatrix} s_L & s_{L-1} & \cdots & s_1 \\ \vdots & \vdots & \vdots & \vdots \\ s_T & s_{T-1} & \cdots & s_{T-L} \end{bmatrix} \quad [8]$$

Upon completion of the block S**32**, the adaptive TDFE **10** proceeds to a block S**34** to compute the $f^{(1)}$ filter **12** and the $b^{(1)}$ filter **15** as a function of the channel coefficients. In one embodiment, the $f^{(1)}$ filter **12** and the $b^{(1)}$ filter **15** are computed in accordance with the following equations [9] and [10]:

$$f^{(1)}=(\hat{H}_{1\delta}\hat{H}_{1\delta}^H+\hat{\sigma}_n^2 I)^{-1}\hat{h}_\delta \quad [9]$$

$$b^{(1)}(k)=\begin{cases} 0, & k=1:\delta-1 \\ (f^{(1)})^H\hat{h}_k, & k=\delta:N_f+L-1 \end{cases} \quad [10]$$

where the $H_{1:\delta}$ represents columns in 1 through δ of the estimated channel matrix H; $\hat{h}_k$ represents the k^{th} column of the estimated channel matrix H; and $\hat{h}_\delta$ represents the the δ^{th} column of the estimated channel matrix H.

Upon completion of the block S**34**, the adaptive TDFE **10** proceeds to a block S**36** wherein the packet y and the soft estimates $s^{(1)}(i)$ are filtered through the $f^{(1)}$ filter **12** and the $b^{(1)}$ filter **15**, respectively, to obtain DFE outputs $z^{(1)}(i)$. In one embodiment, the adder **13** provides the DFE outputs $z^{(1)}(i)$ in accordance with the following equation [11]:

$$z^{(1)}(i)=(f^{(1)})^H y(i)+(b^{(1)})^H\hat{s}^{(1)}(i) \quad [11]$$

where the soft estimate module **14** estimates the soft feedback symbols $\hat{s}^{(1)}(i)$ in accordance with the following equations [12]–[17]:

$$\hat{s}^{(1)}(i) \equiv E[z^{(i)}(i)\,|\,s(i)] = \sum_{k=0}^{7} P\left(z^{(1)}(i)\,|\,s(i)=e^{j\frac{\pi k}{4}}\right)\cdot e^{j\frac{\pi k}{4}} \quad [12]$$

$$P\left(z^{(1)}(i)\,|\,s(i)=e^{j\frac{m\pi}{4}}\right)=\prod_{k=1}^{3} P\left(z^{(1)}(i)\,|\,d_k(s(i))=d_k\left(e^{j\frac{m\pi}{4}}\right)\right), \quad [13]$$

for $m=0, 1, \ldots 7$

$$P(z^{(1)}(i)\,|\,d_k(s(i))=\pm 1)=\sum_{s\in\Omega^\pm} k_s\frac{1}{\sqrt{2\pi\sigma^2}}\exp\left(\frac{-|z^{(1)}(i)-\mu s|^2}{\sigma^2}\right), \quad [14]$$

$$k_s=\frac{P(\text{Transmitted Symbol}=s)}{\sum_{s'\in\Omega^\pm} P(\text{Transmitted Symbol}=s')} \quad [15]$$

$$E[z^{(1)}(i)\|s(i)]=\mu s(i)=|(f^{(1)})^H h_\delta|s(i) \quad [16]$$

$$Var[z^{(1)}(i)\|s(i)]=\sigma^2=\sigma_n^2\|f^{(1)}\|^2+\|(f^{(1)})^H H_{1\delta}\|^2 \quad [17]$$

where $\{d_k(s(i)), k=1, 2, 3\}$ are the bits which correspond to $s^{(1)}(i)$; $\Omega^\pm$ is the set of symbols which correspond to the value of $d_k(s(i))$; and k_s is a normalization factor.

Upon completion of the block S**36**, the adaptive TDFE **10** proceeds to a block S**38** of the flowchart **30** to set switch **16** to provide the output $z^{(1)}(i)$ to the buffer **17**. In response thereto, the buffer **17** stores the DFE outputs $z^{(1)}(i)$.

Upon completion of the block S**38**, the adaptive TDFE **10** proceeds to a block S**40** of the flowchart **30** to generate a priori probabilities $P\{z^{(n)}(i)|d_k(s(i))\}$. In one embodiment, the priori module **18** generates the a priori probabilities $P\{z^{(n)}(i)|d_k(s(i))\}$. in accordance with the following equations [18]–[21]

$$\mu_m = \frac{1}{M+T}\sum_{i=0}^{M+t-1} |(\hat{s}^{(n)}(i))^* z^{(n)}(i)| \qquad [18]$$

$$\sigma_m^2 = \frac{1}{M+T}\sum_{i=0}^{M+T-1} |(\hat{s}^{(n)}(i))^* z^{(n)}(i) - \mu_m|^2 \qquad [19]$$

$$P(z^{(1)}(i) \mid d_k(s(i)) = \pm 1) = \sum_{s\in\Omega^\pm} k_s \frac{1}{\sqrt{2\pi\sigma_m^2}} \exp\left(\frac{-|z^{(1)}(i) - \mu_m s|^2}{\sigma_m^2}\right), \qquad [20]$$

$$k_s = \frac{P(\text{Transmitted Symbol} = s)}{\sum_{s'\in\Omega^\pm} P(\text{Transmitted Symbol} = s')} \qquad [21]$$

Upon completion of block S**40**, the adaptive TDFE **10** proceeds to a block S**42** of the flowchart **30** wherein the de-interleaver **19** conventionally de-interleaves the a priori probabilities $P\{z^{(n)}(i)|d_k(s(i))\}$ and feeds them to the MAP decoder **20**. In response thereto, during a block S**44** of the flowchart **30**, the MAP decoder **20** generates a soft estimate of the bits in the form of a posteriori probabilities $P\{d_k(s(i))|z^{(1)}\}$. In one embodiment, the MAP decoder **20** implements a conventional Bahl-Coch-Jelinek-Raviv ("BCJR") algorithm to generate a posteriori probabilities $P\{d_k(s(i))|z^{(1)}\}$.

The flowchart **30** is terminated upon completion of block S**44**.

Referring to FIGS. **1** and **3**, the adaptive TDFE **10** has a second component stage for executing the flowchart **50** immediately upon termination of the flowchart **30**. The second component stage includes the switch **16**, the buffer **17**, the a priori module **18**, the de-interleaver **19**, the MAP decoder **20**, a switch **21**, and an interleaver **22**. The second component stage further includes a soft estimates module **23**, a filter coefficients module **24**, a feedback filter **25** ("$b^{(n)}$ filter **25**"), a feed-forward filter **26** ("$f^{(n)}$ filter **26**"), and an adder **27** constituting an adaptive decision feedback equalizer.

During a block S**52** of the flowchart **50**, the switch **21** is set to provide the a posteriori probabilities $P\{d_k(s(i))|z^{(n)}\}$ to the interleaver **22**. In response thereto, the interleaver **22** conventionally interleaves the a posteriori probabilities $P\{d_k(s(i))|z^{(n)}\}$. Upon completion of the block S**52**, the adaptive TDFE **10** proceeds to a block S**54** of the flowchart **50** wherein the soft estimates module **23** computes soft estimates of the transmitted symbols $s^{(n)}(i)$ in accordance with the following equations [22] and [23]:

$$\hat{s}^{(n)}(i) \equiv E[s(i) \mid z^{(n)}] = \sum_{k=0}^{7} P\left(s(i) = e^{j\frac{\pi k}{4}} \,\middle|\, z^{(n)}\right) \cdot e^{j\frac{\pi k}{4}} \qquad [22]$$

$$P\left(s(i) = e^{j\frac{m\pi}{4}} \,\middle|\, z^{(n)}\right) = \prod_{k=1}^{3} P\left(d_k(s(i)) = d_k\left(e^{j\frac{m\pi}{4}}\right) \,\middle|\, z^{(n)}(i)\right), \qquad [23]$$

for $m = 0, 1, \ldots 7$

Upon completion of block S**54**, the adaptive TDFE **10** proceeds to block S**56** of the flowchart **50** wherein the filter coefficients module **24** computes the $b^{(n)}$ filter **25** and the $f^{(n)}$ filter **26** in accordance with the following equations [24]–[27]:

$$x = \begin{bmatrix} y(i) \\ \hat{s}_\delta^{(n)}(i) \end{bmatrix} \qquad [24]$$

$$\begin{bmatrix} f^{(n)} \\ b^{(n)} \end{bmatrix} = R_{xx}^{-1} R_{x\hat{s}^{(n)}}, \text{ where} \qquad [25]$$

$$R_{xx} = \sum_{i=0}^{M-1} x(i) x^H(i) \qquad [26]$$

$$R_{x\hat{s}^{(n)}} = \sum_{i=0}^{M-1} x(i) (\hat{s}^{(n)}(i))^* \qquad [27]$$

where $\hat{s}_\delta^{(n)}(i)$ is the vector $\hat{s}^{(n)}(i)$ whose δ^{th} element has been set to zero.

Upon completion of the block S**56**, the adaptive TDFE **10** proceeds to a block S**58** of the flowchart **50** wherein the packet y and the soft symbol estimates $s^{(n)}(i)$ are filtered through the $f^{(n)}$ filter **26** and the $b^{(n)}$ filter **25**, respectively, to obtain DFE outputs $z^{(n)}(i)$. In one embodiment, the adder **27** computes the DFE outputs $z^{(n)}(i)$ in accordance with the following equation [28]:

$$z^{(n)}(i) = (f^{(n)})^H y(i) + (b^{(n)})^H \hat{s}^{(n)}(i) \qquad [28]$$

Upon completion of the block S**58**, the adaptive TDFE **10** proceeds to a block S**60** of the flowchart **50** to set switch **16** to provide the DFE outputs $z^{(n)}(i)$ to the buffer **17**. In response thereto, the buffer **17** stores the DFE outputs $z^{(n)}(i)$.

Upon completion of the block S**60**, the adaptive TDFE **10** proceeds to a block S**62** of the flowchart **50** to generate a priori probabilities $P\{z^{(n)}(i)|d_k(s(i))\}$. In one embodiment, the priori module **18** generates the a priori probabilities $P\{z^{(n)}(i)|d_k(s(i))\}$ in accordance with the following equations [29]–[31]

$$\mu_m = \frac{1}{M+T}\sum_{i=0}^{M+T-1} \left|(\hat{s}^{(n)}(i))^* z^{(n)}(i)\right| \qquad [29]$$

$$\sigma_m^2 = \frac{1}{M+T}\sum_{i=0}^{M+T-1} \left|(\hat{s}^{(n)}(i))^* z^{(n)}(i) - \mu_m\right|^2 \qquad [30]$$

$$P(z^{(1)}(i)) \mid d(i,j)) = \pm 1 \cong \sum_{S\in\Omega} \frac{1}{\sqrt{2\pi\sigma_m^2}} \exp\left(\frac{-|z^{(1)}(i) - \mu_m s|^2}{\sigma_m^2}\right) \qquad [31]$$

Upon completion of block S**62**, the adaptive TDFE **10** proceeds to a block S**64** of the flowchart **50** wherein the de-interleaver **19** conventionally de-interleaves a priori probabilities $P\{z^{(n)}(i)|d_k(s(i))\}$ and feeds them to the MAP decoder **20**. In response thereto, during a block S**66** of the flowchart **50**, the MAP decoder **20** generates either a soft estimate of the bits in the form of a posteriori probabilities $P(d_k(s(i))|z^{(n)})$. In one embodiment, the Map decoder **20** implements a BCJR algorithm to generate a posteriori probabilities $P\{d_k(s(i)|z^{(n)}\}$.

The flowchart **50** is immediately terminated upon a completion of the block S**66** when only one iteration of blocks S**52**–S**66** is contemplated. With one completed iteration, the switch **21** is set to provide the a posteriori probabilities $P(d_k(s(i))|z^{(n)})$ as hard estimates $\hat{b}(i)$ of the bits. Thus, the soft symbol estimates $s^{(n)}(i)$, the $b^{(n)}$ filter **25** and the $f^{(n)}$ filter **26** are computed only once when only one iteration of blocks S**52**–S**66** is contemplated.

Preferably, the flowchart **50** is terminated after plurality of n iterations (e.g., 4 iterations) of the blocks S**52**–S**66** as shown in FIG. **3**. As such, the switch **21** is set to provide the a posteriori probabilities $P\{d_k(s(i)|z^{(n)}\}$ to the interleaver **22** upon completion of each intermediate iteration of the blocks S**52**–S**66**, and the switch **21** is set to provide the a posteriori probabilities $P\{d_k(s(i)|z^{(n)}\}$ as hard estimates $\hat{b}(i)$ of the bits upon completion of the final iteration of the blocks S**52**–S**66**. Those having ordinary skill in the art will appreciate the repeated computations of the soft symbol estimates $s^{(n)}(i)$, the $b^{(n)}$ filter **25** and the $f^{(n)}$ filter **26** during the multiple iterations of the blocks S**52**–S**66** in effect produce separate and distinct soft symbol estimates $s^{(n)}(i)$, $b^{(n)}$ filters **25** and $f^{(n)}$ filters **26** for each iteration.

The illustrated embodiments of the present invention may be implemented in hardware, software stored on a computer readable medium, or combinations of hardware and software. The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

We claim:

1. A method for decoding a packet transmitted over a channel, the packet including a plurality of samples, said method comprising:

in a first iteration, generating a first set of soft estimates of bits based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimate of the channel; and

in a second iteration, generating a second set of soft estimates of bits based upon a computation of a second feed-forward filter and a second feedback filter as a function of a first set of soft symbol estimates obtained during the first iteration.

2. The method of claim **1**, further comprising:

generating a set of hard estimates of bits based upon a computation of the second feed-forward filter and the second feedback filter as a function of a second set of soft symbol estimates.

3. A device for decoding a packet transmitted over a channel, the packet including a plurality of samples, said device comprising:

means for generating in a first iteration, a first set of soft estimates of bits based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimate of the channel; and

means for generating in a second iteration, a second set of soft estimates of bits based upon a computation of a second feed-forward filter and a second feedback filter as a function of a first set of soft symbol estimates obtained during the first iteration.

4. The device of claim **3**, further comprising:

means for generating a set of hard estimates of bits based upon a computation of the second feed-forward filter and the second feedback filter as a function of a second set of soft symbol estimates.

5. A method for decoding a packet transmitted over a channel, the packet including a plurality of samples, said method comprising:

providing a first set of soft symbol estimates; and

computing a feed-forward filter and a feedback filter as a function of the first set of soft symbol estimates;

wherein the feed-forward filter and the feedback filter are computed according to:

$$x = \begin{bmatrix} y(i) \\ \hat{s}_\delta^{(n)}(i) \end{bmatrix}$$

$$\begin{bmatrix} f^{(n)} \\ b^{(n)} \end{bmatrix} = R_{xx}^{-1} R_{x\hat{s}^{(n)}}, \text{ where}$$

$$R_{xx} = \sum_{i=0}^{M-1} x(i)x^H(i)$$

$$R_{x\hat{s}^{(n)}} = \sum_{i=0}^{M-1} x(i)\left(\hat{s}^{(n)}(i)\right)^*$$

wherein y(i) is the samples, $\hat{s}_\delta^{(n)}(i)$ is the soft symbol estimate whose δth delay element has been set to zero, $f^{(n)}$ is the feed-forward filter, and $b^{(n)}$ is the feedback filter, M is a number of data symbols in a packet and H is a Hermitian transpose.

6. The method of claim **5**, further comprising:

filtering the plurality of samples through the feed-forward filter; and

filtering the first set of soft symbol estimates through the feedback filter.

7. The method of claim **6**, further comprising:

providing a first set of decision feedback equalization outputs in response to a filtering of the plurality of samples through the feed-forward filter and a filtering of the first set of soft symbol estimates through the feedback filter.

8. The method of claim **7**, wherein the a first set of decision feedback equalization outputs are computed according to:

$$z^{(n)}(i)=(f^{(n)})^H y(i)+(b^{(n)})^H \hat{s}^{(n)}(i).$$

9. The method of claim **7**, further comprising:

providing a second set of soft symbol estimates; and

computing the feed-forward filter and the feedback filter as a function of the second set of soft symbol estimates.

10. The method of claim **9**, further comprising:

filtering the plurality of samples through the feed-forward filter; and

filtering the second set of soft symbol estimates through the feedback filter.

11. The method of claim **10**, further comprising:

providing a second set of decision feedback equalization outputs in response to a filtering of the plurality of samples through the feed-forward filter and a filtering of the second set of soft symbol estimates through the feedback filter.

12. A device for decoding a packet transmitted over a channel, the packet including a plurality of samples, said device comprising:

a soft symbol estimator providing a first set of soft symbol estimates in response to a reception of the packet by said device;

a feed-forward filter computed as a function of the first set of soft symbol estimates; and

a feedback filter computed as a function of the first set of soft symbol estimates;

wherein said feed-forward filter and said feedback filter are computed according to:

$$x = \begin{bmatrix} y(i) \\ \hat{s}_{\delta}^{(n)}(i) \end{bmatrix}$$

$$\begin{bmatrix} f^{(n)} \\ b^{(n)} \end{bmatrix} = R_{xx}^{-1} R_{x\hat{s}^{(n)}}, \text{ where}$$

$$R_{xx} = \sum_{i=0}^{M-1} x(i)x^H(i)$$

$$R_{x\hat{s}^{(n)}} = \sum_{i=0}^{M-1} x(i)\left(\hat{s}^{(n)}(i)\right)^*$$

wherein y(i) is the samples, $\hat{s}_{\delta}^{(n)}(i)$ is the soft symbol estimate whose δth delay element has been set to zero, $f^{(n)}$ is the feed-forward filter, and $b^{(n)}$ is the feedback filter, M is a number of data symbols in a packet and H is a Hermitian transpose.

13. The device of claim **12**, wherein

said feed-forward filter filters the plurality of samples upon a computation of said feed-forward filter; and

said feedback filter filters the first set of soft symbol estimates upon a computation of said feedback filter.

14. The device of claim **13**, further comprising:

an adder providing a first set of decision feedback equalization outputs in response to a filtering of the plurality of samples through said feed-forward filter and a filtering of the first set of soft symbol estimates through said feedback filter.

15. The device of claim **14**, wherein the a first set of decision feedback equalization outputs are computed in according to:

$$z^{(n)}(i)=(f^{(n)})^H y(i)+(b^{(n)})^H \hat{s}^{(n)}(i).$$

16. The device of claim **14**, wherein:

said feed-forward filter is computed as a function of a second set of soft symbol estimates;

said feedback filter is computed as a function of the second set of soft symbol estimates,

said soft symbol estimator provides the second set of soft symbol estimates in response to said adder providing said first set of decision feedback equalization outputs.

17. The device of claim **16**, wherein:

said feed-forward filters the plurality of samples upon a computation of said feed-forward filter; and

said feedback filter filters the second set of soft symbol estimates upon a computation of said feedback filter.

18. The device of claim **17**, wherein

said adder further provides a second set of decision feedback equalization outputs in response to a filtering of the plurality of samples through said feed-forward filter and a filtering of the second set of soft symbol estimates through said feedback filter.

19. A computer readable medium storing a computer executable program code, the code, when executed, performing the steps comprising:

generating during a first iteration, a first set of soft estimates of a plurality of bits based upon a computation of a first feed-forward filter and a first feedback filter as a function of an estimate of a channel; and

generating during a second iteration, a second set of soft estimates of the plurality of bits based upon a computation of a second feed-forward filter and a second feedback filter as a function of a first set of soft symbol estimates obtained during the first iteration.

20. The computer readable medium of claim **19**, further comprising:

generating a set of hard estimates of the plurality of bits based upon a computation of the second feed-forward filter and the second feedback filter as a function of a second set of soft symbol estimates.

21. A computer readable medium storing a computer executable program code, the code, when executed, performs the steps comprising:

providing a first set of soft symbol estimates; and

computing a feed-forward filter and a feedback filter as a function of the first set of soft symbol estimates;

wherein the first feed-forward filter and the first feedback filter are computed according to:

$$x = \begin{bmatrix} y(i) \\ \hat{s}_{\delta}^{(n)}(i) \end{bmatrix}$$

$$\begin{bmatrix} f^{(n)} \\ b^{(n)} \end{bmatrix} = R_{xx}^{-1} R_{x\hat{s}^{(n)}}, \text{ where}$$

$$R_{xx} = \sum_{i=0}^{M-1} x(i)x^H(i)$$

$$R_{x\hat{s}^{(n)}} = \sum_{i=0}^{M-1} x(i)\left(\hat{s}^{(n)}(i)\right)^*$$

wherein y(i) is the samples, $\hat{s}_{\delta}^{(n)}(i)$ is the soft symbol estimate whose δth delay element has been set to zero, $f^{(n)}$ is the feed-forward filter, and $b^{(n)}$ is the feedback filter, M is a number of data symbols in a packet and H is a Hermitian transpose.

22. The computer readable medium of claim **21**, further comprising:

filtering the plurality of samples through the feed-forward filter; and

filtering the first set of soft symbol estimates through the feedback filter.

23. The computer readable medium of claim **22**, further comprising:

providing a first set of decision feedback equalization outputs in response to a filtering of the plurality of samples through the feed-forward filter and a filtering of the first set of soft symbol estimates through the feedback filter.

24. The computer readable medium of claim **23**, wherein the a first set of decision feedback equalization outputs are computed according to:

$$z^{(n)}(i)=(f^{(n)})^H y(i)+(b^{(n)})^H \hat{s}^{(n)}(i).$$

25. The computer readable medium of claim **23**, further comprising:

providing a second set of soft symbol estimates; and

computing the feed-forward filter and the feedback filter as a function of the second set of soft symbol estimates.

26. The computer readable medium of claim **25**, further comprising:

filtering the plurality of samples through the feed-forward filter; and

filtering the second set of soft symbol estimates through the feedback filter.

27. The computer readable medium of claim **26**, further comprising:

providing a second set of decision feedback equalization outputs in response to a filtering of the plurality of samples through the feed-forward filter and a filtering of the second set of soft symbol estimates through the feedback filter.

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